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GEOLOGIC ROAD GUIDE TO SHEEP CREEK CANYON GEOLOGICAL AREA, NORTHEASTERN UTAH

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INTRODUCTION

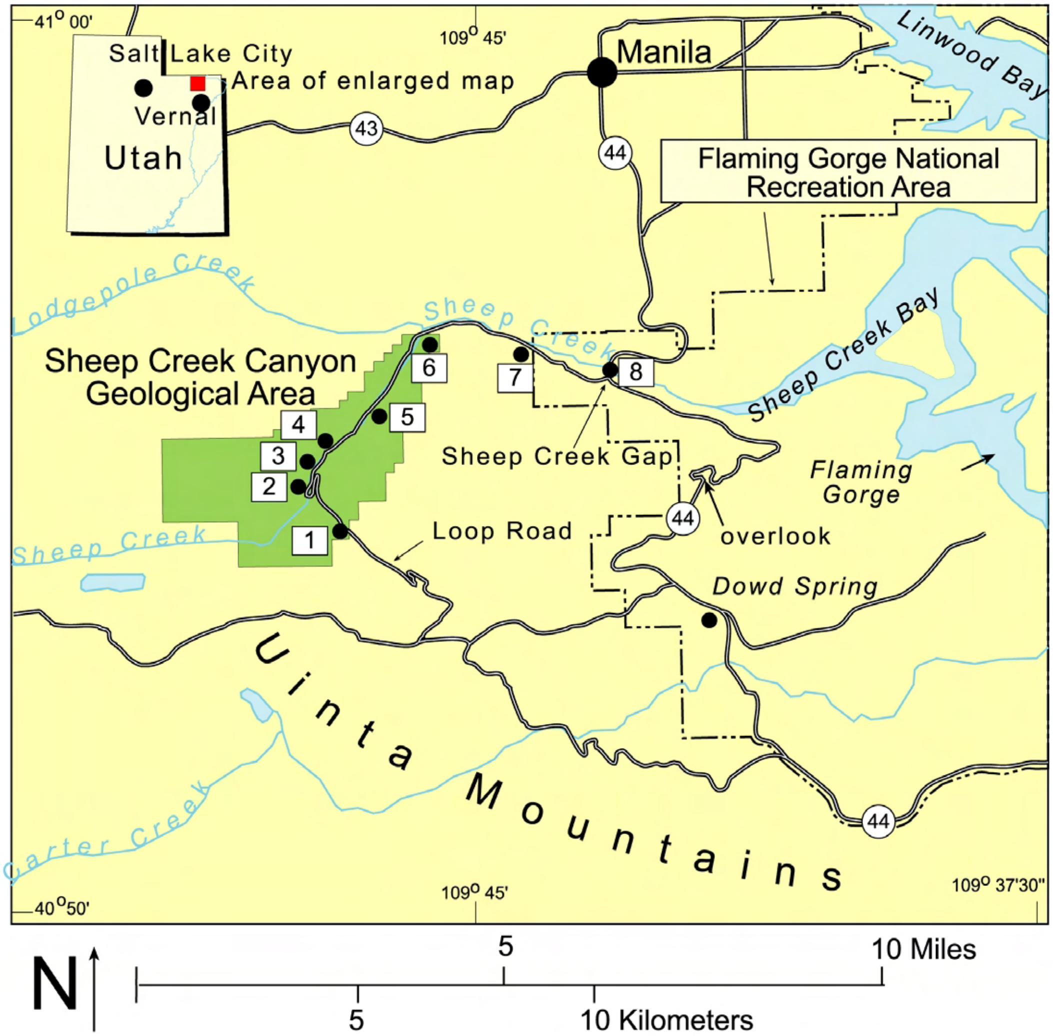
The U.S. Forest Service designated nearly 3,600 acres of land as the Sheep Creek Canyon Geological Area on May 13, 1962, to preserve the spectacular geology of the canyon for future generations. This remarkable area is located along part of the Sheep Creek drainage west of Flaming Gorge National Recreation Area (figure 1). Sheep Creek Canyon is an excellent place to learn about the Earth's geologic history.

Sheep Creek Canyon Geological Area is on the north flank of the eastern Uinta Mountains. The peaks in this part of the Uintas are generally below 10,000 feet in elevation, which is less than the high peaks of the western part, but are still impressive. The elevation rises to about 9,000 feet along a ridge in the southwestern part of the geological area and drops to 6,400 feet in the northeast part of the geological area where Sheep Creek enters the broader, alluviated valley of the lower Sheep Creek Canyon. The geological area contains one road that is part of a loop that connects with Utah Highway 44 near Dowd Spring on the south and at Sheep Creek Gap on the north.

Several early investigations explored the vast western territories after the Civil War to describe the geology and other natural resources. Three of the competing "Great Four" U.S. Government surveys studied the eastern Uinta Mountains between 1869 and 1875 (Hansen, 1975). These included the "King survey" in 1869 and 1871, the "Hayden survey" in 1870, and the "Powell survey" in 1869, 1871, 1874, and 1875—although Powell first visited the area in 1868. The geologic work of S.F. Emmons (1877), as part of the "King survey," most completely described the geology of the Uinta Mountains; however, it was Powell's work (Powell, 1875, 1876) that most people remember because of his insightful geologic observations and his first-ever exploration of the Green and Colorado Rivers by boat (Hansen, 1975).

Since the Powell, King, and Hayden surveys, many more geological investigations stimulated by scientific curiosity and the search for minerals and petroleum have been conducted in and around the geological area. A summary of the early geologic work can be found in Hansen (1965). Schell (1969) and Sprinkel and others (2000) specifically describe the geology of the Sheep Creek Canyon Geological Area.

Figure 1. Index map of Sheep Creek Canyon Geological Area, northeastern Utah, showing key geographic features and STOP locations discussed in the text. STOP numbers correspond to the numbered boxes.



More than one billion years of geologic history are showcased within the geological area, from rocks deposited in an ancient rift system in which the landscape was likely stark and barren of visible life to the classic faults and folds of the Laramide orogeny that uplifted the Uinta Mountains about 70 to 40 million years ago (figure 2). Nine formations that comprise about 8,000 feet of rock are exposed in northwest-trending bands that dip northeastward; the oldest rocks are exposed in the southern part of the geological area and the bands of rock become younger to the north (figure 3).

The oldest rocks in Sheep Creek Canyon comprise the Middle and Upper Proterozoic Uinta Mountain Group. These rocks are 1.1 to 0.8 billion years old and were deposited during a period of rifting. After deposition of the Uinta Mountain Group, a prolonged period—about 450 million years—of interspersed deposition and erosion occurred, with erosion prevailing. Any rocks deposited during this time were later eroded. Sediments of Mississippian age spread across the unconformable (erosion) surface formed on the Uinta Mountain Group as oceans swept across the region. Marine conditions dominated the rest of the Paleozoic Era, with an interruption during Late Pennsylvanian to Early Permian time as the eolian Weber Sandstone was deposited. The youngest rocks in the geological area belong to the Triassic Dinwoody Formation.

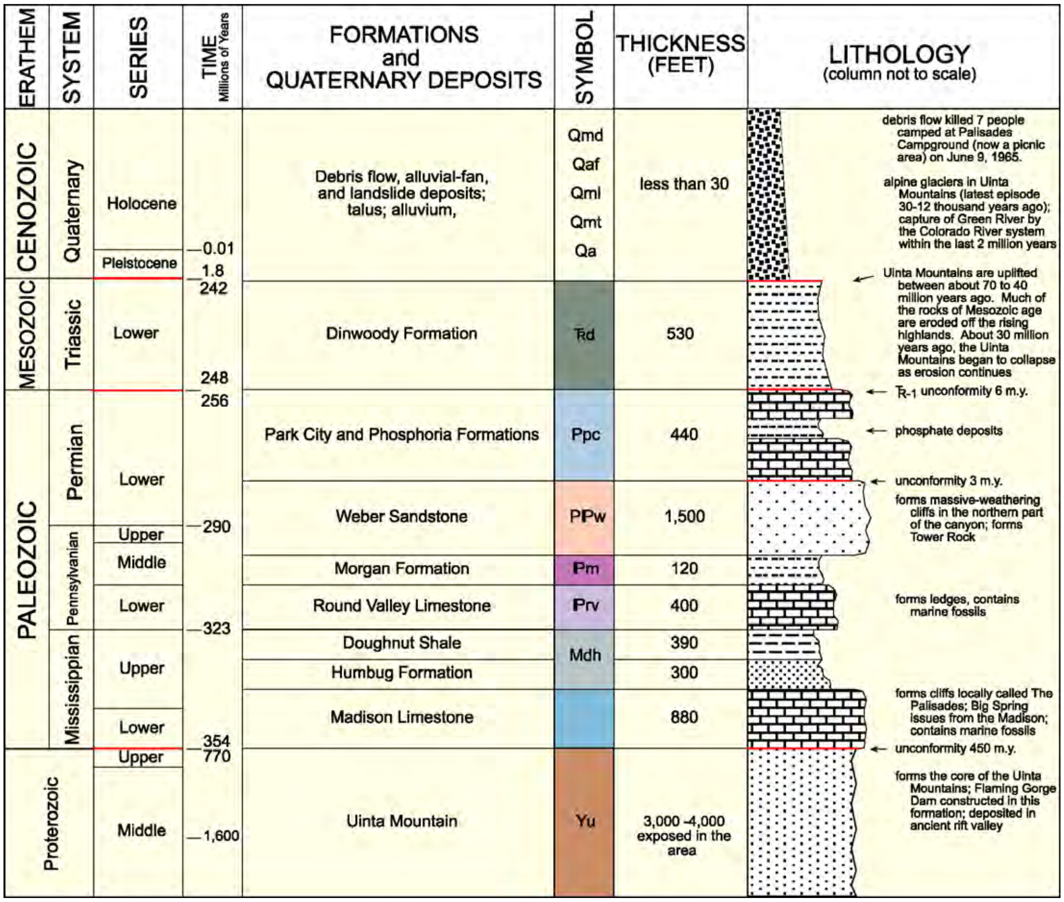


Figure 2. Stratigraphic column of rock formations and Quaternary deposits within Sheep Creek Canyon Geological Area (modified from Hansen, 1965; Schell, 1969). The horizontal red lines in the "Series" and "Lithology" columns represent unconformities.

The Uinta Mountains rose along the Uinta fault zone during latest Cretaceous through early Tertiary time. As they rose, stresses tilted Precambrian, Paleozoic, and Mesozoic rocks steeply northward, folded them into monoclines, and faulted the rocks. Thousands of feet of rock eroded from the growing highlands, eventually exposing the Precambrian core of the Uinta Mountains.

The landscape and drainage system of the Flaming Gorge area continued to change as the area was scoured forming the Gilbert Peak erosion surface during Oligocene time—about 30 million years ago—and was later tilted during Miocene extension of the Uinta Mountains. Renewed uplift of the Colorado Plateau during Basin and Range extension that began during late Miocene time—about 15 to 10 million years ago—rejuvenated the upper Colorado River Basin and caused active headward erosion of many rivers.

Evidence of a changing landscape, along with the animals that flourished and died there, is preserved in the rocks that form the spectacular scenery of Sheep Creek Canyon. Examples of shallow tropical marine environments, vast sand dune fields, and coastal environments are all exposed within the geological area. Sheep Creek Canyon Geological Area also showcases examples of deformation dominated by the classic faults and folds associated with the Laramide orogeny.

START AT THE INTERSECTION OF UTAH HIGHWAY 44 AND U.S. FOREST SERVICE (USFS) ROAD 218. USFS ROAD 218 BEGINS THE SHEEP CREEK CANYON GEOLOGICAL AREA LOOP. THIS PART OF THE LOOP BEGINS IN THE MANILA 7.5-MINUTE QUADRANGLE.

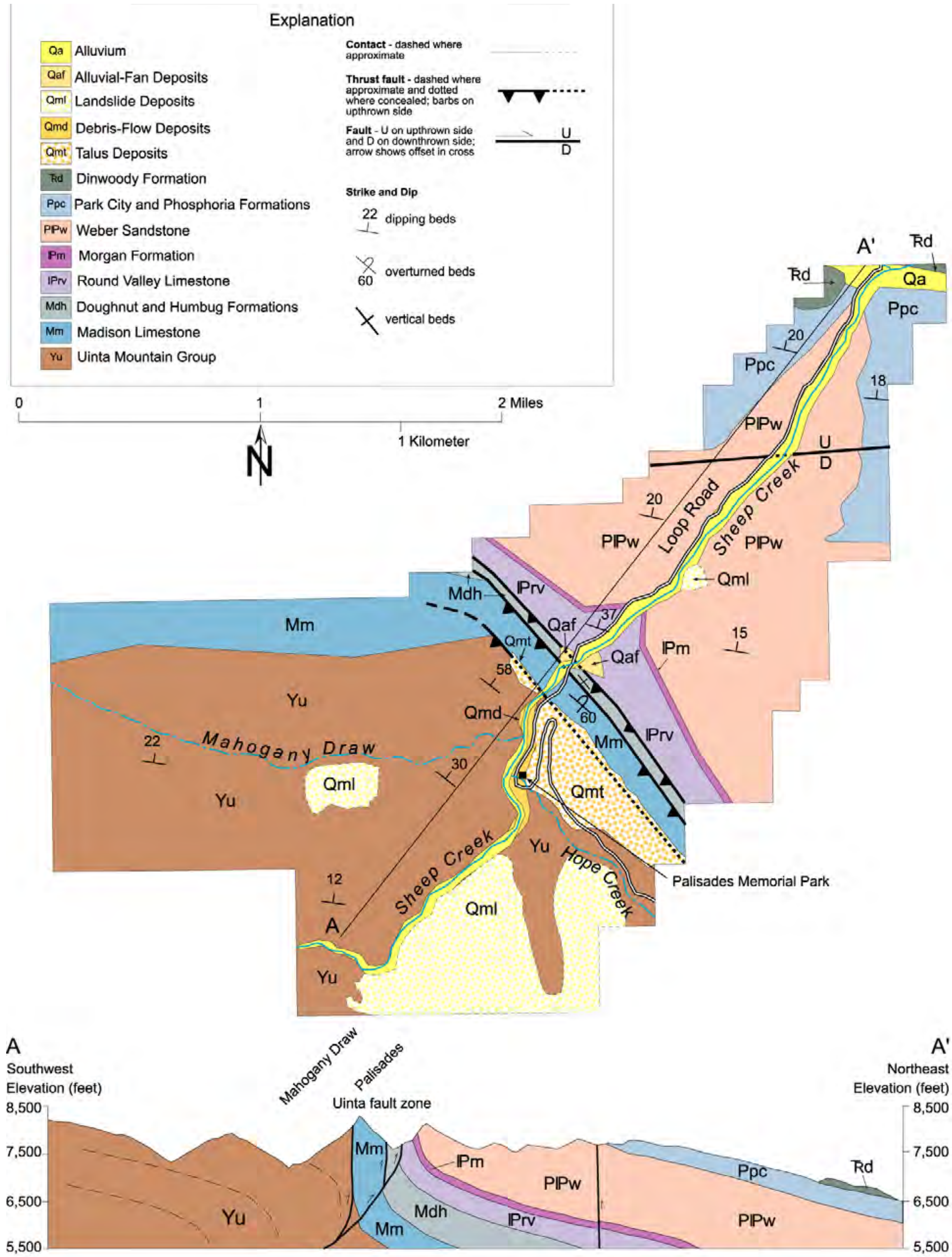


Figure 3. Generalized geologic map and schematic cross section of Sheep Creek Canyon Geological Area; modified from Hintze and others (2000).

MILEAGE INCREMENT	CUMULATIVE	DESCRIPTION
0.0	0.0	Intersection of Utah Highway 44 and U.S. Forest Service (USFS) road 218.
0.1	0.1	**Cattle guard**; Middle and Upper Proterozoic Uinta Mountain Group crops out on the right. These rocks were deposited by fluvial (river) processes in a rift valley where the Uinta Mountain Group is more than 24,000 feet thick. Only 3,000 to 4,000 feet of the Uinta Mountain Group is exposed in the Sheep Creek Canyon area (figure 2).
0.1	0.2	Road cut in red quartz sandstone of the Uinta Mountain Group. The beds exposed in the road cut strike north 40 to 50 degrees east and dip about 30 degrees northwest. These beds, as well as rocks in the Sheep Creek Canyon Geological Area, form the north flank of the Uinta arch, a broad asymmetrical anticline about 30 miles wide and 160 miles long (Hansen, 1965; Sprinkel, 2000). The Uinta arch actually consists of two large domes that are aligned east-west and separated by a shallow structural saddle, which is crossed by U.S. Highway 191-Utah Highway 44 from Vernal to Manila (Hansen, 1965; Sprinkel, 2000). Thus, the Sheep Creek Canyon Geological Area is on the eastern part of the western dome. **Continue west on USFS road 218**, which follows along a hill that contains many road cuts that expose the Uinta Mountain Group.
1.7	1.9	**Summit Springs**. Turnout with USFS information kiosk.
0.1	2.0	Intersection of USFS road 364 and access road to USFS guard station. **Stay on the paved road (USFS 218)**.
0.3	2.3	**Cattle guard**; Uinta Mountain Group crops out in the area. The poorly vegetated hill to the north (on horizon) is called Windy Ridge. The south-facing slope of Windy Ridge consists of the Mississippian Madison Limestone; however, the Uinta fault zone is above the Spring Creek drainage just below the Madison outcrops.
0.4	2.7	Intersection of USFS 364 road and the access road to Summit Spring Guard Station. **Continue west on USFS road 218**.
0.3	3.0	Intersection of Spirit Lake road (USFS 221) and Deep Creek road (USFS 539). **Continue west on USFS road 218**. The road is still crossing the Uinta Mountain Group.
0.5	3.5	Headwater of Hope Creek, which is spring fed. Road cut in Uinta Mountain Group on left. The beds strike north 50 degrees west and dip 62 degrees northeast.
0.3	3.8	Intersection of USFS road 93 (Death Valley road). **Continue west on USFS road 218**.

0.3 4.1 Beginning of switchback. View to the west-northwest of Sheep Creek and Mahogany Draw in the Sheep Creek Canyon Geological Area. The deep red rocks are the quartz sandstone beds of the Uinta Mountain Group. The steep hill north of the road is Windy Ridge. Windy Ridge consists of steeply dipping and overturned beds of the Mississippian Madison Limestone. The road is built on the Uinta Mountain Group. The Uinta fault zone is near the base of the Madison Limestone.

2.0 6.1 **Cattle guard**.

0.4 6.5 **STOP 1** - Boundary of Sheep Creek Canyon Geological Area and Palisades Memorial Park overlook (figure 4). To the south, Sheep Creek flows down a relatively narrow canyon. A steep cliff of Uinta Mountain Group forms the west bank, and the west margin of a large landslide forms the east bank (figure 3). Poor exposures and hummocky topography characterize the landslide area. At this point, Sheep Creek Canyon widens and forms an amphitheater because the tributary drainages of Mahogany Draw and Hope Creek have eroded the Uinta Mountain Group along strike. The Uinta Mountain Group consists of the red quartz sandstone, siltstone, and mudstone beds that form the bowl of the amphitheater. A conspicuous white and red banded to mottled sandstone within the Uinta Mountain Group can be seen from the overlook. Schell (1969) believed that ground water bleaching is likely responsible for the light color. The rim of the amphitheater is formed by the gray cliff of the Mississippian Madison Limestone, which is locally referred to as The Palisades. The southwestern branch of the Uinta fault zone placed the Uinta Mountain Group (on the south) next to the Madison Limestone (see STOP 3). Westward, the fault dies out and the Madison unconformably overlies the Uinta Mountain Group. The overlook also provides a good view of the debris-flow deposit that destroyed the Palisades campground and killed seven campers (figure 5). The debris flow originated about one mile upstream from the campground where east-flowing Sheep Creek makes a turn to the northeast and cuts into a large landslide (figure 3). The overlook provides a view of the narrow part of Sheep Creek Canyon and the approximate location where the debris flow originated. See STOP 2 for a detailed discussion of the debris flow.

Figure 4. Panoramic view of part of Sheep Creek Canyon Geological Area from STOP 1. The southwest branch of the Uinta fault zone (white dashed line with barbs on up thrown side) placed deep red rocks of the Uinta Mountain Group (Yu) up next to the gray rocks of the Mississippian Madison Limestone (Mm) during the Laramide orogeny about 70 to 40 million years ago. The Pennsylvanian Round Valley Formation (IPrv), Pennsylvanian Morgan Formation (IPm), and Pennsylvanian-Permian Weber Sandstone (PIPw) form the ridge on the right side of the photograph. The Madison Limestone cliff is locally called The Palisades. View is to the north.

Figure 5. Debris-flow deposits (Qmd) at Palisades Memorial Park as seen from near STOP 1. The debris flow swept through the Palisade campground on June 9, 1965, destroying the campground and killing seven campers. View is to the southwest.

0.6 7.1 **STOP 2 -** Palisades Memorial Park. Turn into parking area of Palisades Memorial Park to view the memorial to the seven members of a family who died in a tragic debris flow here in 1965. We had reported in another article that the debris flow and the deaths of the campers happened on June 10, 1965, based on local newspaper accounts (Sprinkel and others, 2000). However, the monument at Palisades Memorial Park indicates the event happened on June 9, 1965, and additional research confirms the June 9th date.

Wednesday, June 9, 1965, was stormy with steady rains. The ground was likely already saturated from the melting of a greater-than-normal snow pack, which was still perched in the mountains surrounding the campground due to a late and cool spring, and the wet conditions were aggravated by the heavy rains—a recipe for disaster! The family, camped at Palisade campground (now Palisades Memorial Park) along Sheep Creek, was in their trailer for the night when a devastating debris flow—similar to a flash flood—ripped through the campground. The debris flow destroyed the campground and swept the seven campers away to their death. It continued down Sheep Creek and destroyed five miles of road, three bridges, and four developed campsites. Damage from the debris flow is still evident west of the picnic area near Sheep Creek where twisted water pipes and other metal from the campground are lodged in the debris-flow deposit.

As previously mentioned, the debris flow originated about one mile upstream where east-flowing Sheep Creek makes a turn to the northeast. At that turn, Sheep Creek cuts into a large landslide (figure 3). Schell (1969) reported that the landslide was moving in June 1965 because of abnormally high runoff. It is likely that Sheep Creek, swollen from steady rains and heavy snowmelt, undercut part of the landslide. That may have caused the landslide and residual (soil and colluvium) material to slump into Sheep Creek and move rapidly downstream, scouring more debris (mud, silt, sand, gravel, boulders, and vegetation) from the unstable eastern bank along the way. By the time the debris flow reached the campground, which probably was only a few minutes, it contained a large volume of material; the force of the flow overturned the car and destroyed the trailer belonging to the doomed campers. We estimated that the debris-flow deposit at the south end of the campground was at least 5 feet thick and covered much of the flood plain (figure 5). Debris-flow levees are still preserved east of the picnic area (figure 6). Not known at that time by the campers, the old campsite was located on debris-flow and alluvial deposits. The death of the seven campers from the 1965 debris flow prompted U.S. Forest Service officials to designate the site as Palisades Memorial Park and restrict it to day use only, thus reducing the risk of deaths from future debris flows.

Figure 6. Debris-flow levee west of Palisades Memorial Park at STOP 2. Debris flows build natural levees along their margins as rock material and mud are pushed to the sides of the flow. These levees are often easy to identify because they form a berm that contains a concentration of boulders. Twisted water pipes and other metal from the destroyed campground can still be found in the debris-flow deposit. View is to the south.

0.4 7.5 **STOP 3 -** Southwest branch of Uinta fault zone and Big Spring. The road and Sheep Creek cut through Windy Ridge just below Palisades Memorial Park. The southwest branch of the Uinta fault placed the red Uinta Mountain Group next to the gray Madison Limestone (figure 7). Normally the Madison lies unconformably on the Uinta Mountain Group, but here the Uinta fault has thrust the red quartzite beds of the Uinta Mountain Group northward. Thrusting has folded the beds of the Uinta Mountain Group and pushed the Madison Limestone upward to form steeply dipping to overturned beds.

Big Spring is west of Sheep Creek and the road. The Madison Limestone is a thick-bedded, fractured, and soluble formation in which groundwater can percolate down through the formation to create vugs. Some vugs are minor enlargements of fractures whereas other vugs are more than one foot in diameter.

0.1 7.6 **STOP 4 -** View of the northeastern branch of the Uinta fault zone (figure 8). This branch of the fault zone is complicated and may consist of several small faults. In general, however, the fault zone thrusts the steeply dipping to overturned beds of the Mississippian Humbug and Doughnut Formations over the more gently east-dipping beds of the Pennsylvanian Round Valley and Morgan Formations. The fault is poorly exposed because of surficial cover but it cuts across the lower part of the south-facing slope that is adjacent to the northwest-trending drainage. The gray cliff southwest of the drainage consists of the Madison Limestone. The reddish-colored Humbug Formation crops out between the gray Madison and the drainage. The drainage is cut mostly into the gray and purplish mudstone of the Mississippian Doughnut Shale. Northeast of the drainage, the ledgy gray beds of the Round Valley Limestone, the thin reddish-yellow Morgan Formation, and the lower part of the Weber Sandstone crop out. The Weber forms the steep, massive-weathering cliff.

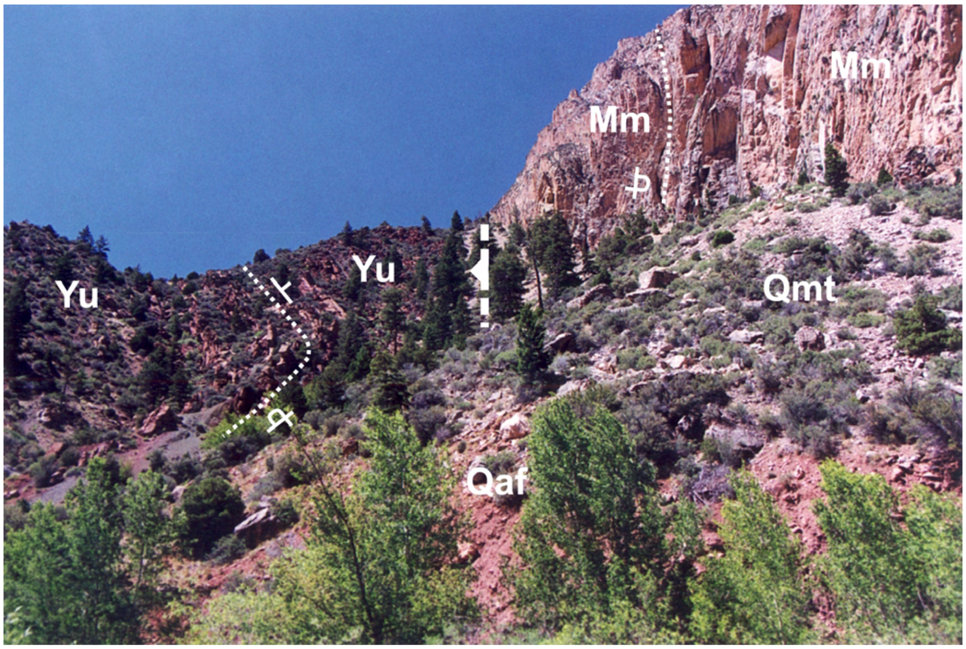


Figure 7. View looking northwest toward the southwestern branch of the Uinta fault zone along the loop road at STOP 3 (compare with the cross section in figure 3); the STOP is less than a mile northeast of Palisades Memorial Park. The red Proterozoic Uinta Mountain Group (Yu) is thrust against the gray Mississippian Madison Limestone (Mm). The structural relations are difficult to visualize in this photograph because of the camera angle, the fault trend, the strike of the rocks, and the less resistant nature of the Uinta Mountain Group as compared to the Madison Limestone. The thrust fault (long-dash line) is mostly covered by talus (Qmt) and alluvial-fan deposits (Qaf) in this photograph, but is near vertical where exposed. Beds of the Uinta Mountain Group steepen northward and are overturned along the fault. Beds of the Madison Limestone (Mm) are vertical to overturned. The short-dash line and strike and dip symbols depict bedding attitudes. The Uinta fault may have originally formed during Middle Proterozoic rifting beginning about 1.5 billion years ago, along the northern margin of the rift valley. Rock relations preserved in the road cut indicate the fault was reactivated with reverse movement during the Laramide orogeny between 70 and 40 million years ago. Down dropping of the Uinta Mountains followed a period of crustal stability that began about 30 to 24 million years ago. Down-to-the-south movement likely continued along the Uinta fault during Miocene time (about 24 to 5 million years ago). View is to the northwest.

0.1 7.7 West of the road, the Pennsylvanian Round Valley Limestone forms the steep ledges that dip northeast and intersect Sheep Creek.

0.2 7.9 A bridge crosses Sheep Creek. The Morgan Formation crops out at stream level. A small syncline is also preserved west of the road.

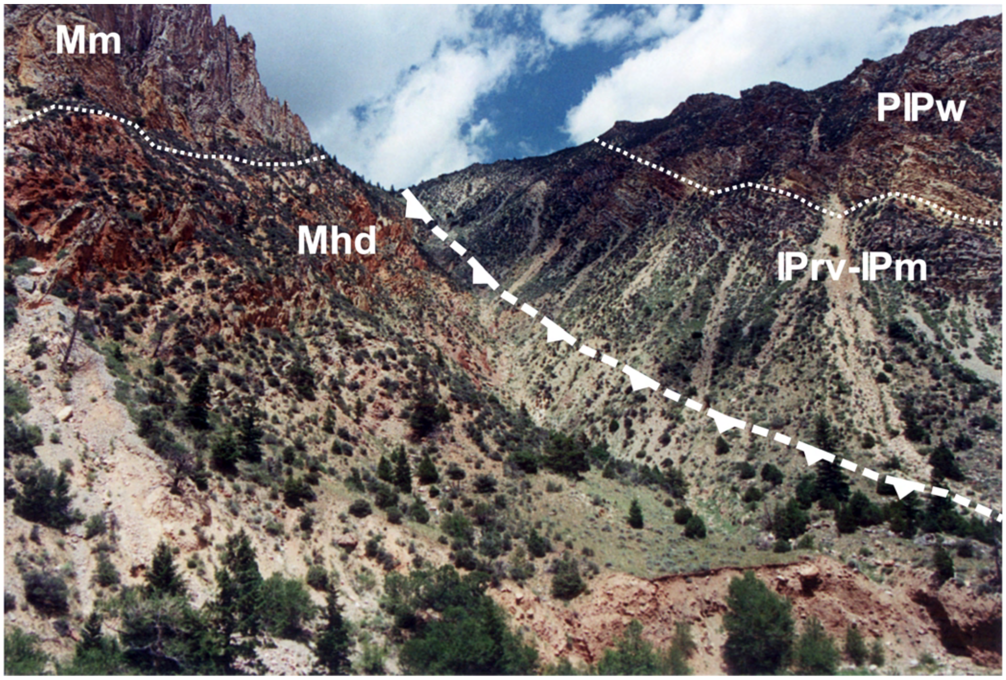


Figure 8. View north at STOP 4 along the loop road of the Pennsylvanian Round Valley Limestone (IPrv) and Pennsylvanian Morgan Formation (IPm) along the northeastern branch of the Uinta fault zone near the center of the photograph. The Pennsylvanian-Permian Weber Sandstone (PIPw) forms the cliffs in the upper right of the photograph and the Mississippian Madison Limestone (Mm) form the cliffs in the left of the photograph. The northeastern branch of the Uinta fault zone is structurally complicated. In general, it dips steeply to the left of the photograph and cuts beneath the outcrops of Madison, Humbug, and Doughnut Formations shown in the left part of the photograph. The several faults placed vertical to steeply northeast-dipping beds of the Mississippian Humbug and Doughnut Formations (Mdh) over moderately dipping Pennsylvanian Round Valley Limestone and Morgan Formations (compare with the cross section in figure 3). The long-dashed line represents the approximate trace of the northeastern branch of the Uinta fault zone (barbs are on the upthrown side). The short-dashed lines are the approximate locations of formation contacts.

0.4 8.3 The lower Weber Sandstone forms the steep cliff along the road.

0.5 8.8 Approximate contact between the lower and upper Weber Sandstone.

0.0 8.8 **STOP 5** - Tower Rock is a hoodoo rock formation in the upper part of the Weber Sandstone (figure 9). Prominent large-scale cross-beds are evident. In Sheep Creek Canyon, the Weber Sandstone can be divided into two units. The lower Weber consists of fine-grained, well-sorted, cross-bedded quartz sandstone and thin beds of limestone. The upper Weber is similar to the lower unit except it does not contain limestone beds and is more highly cross-bedded. In addition, the lower Weber tends to be slightly darker than the upper Weber and weathers into blocky outcrops. The upper Weber is generally lighter and weathers into more rounded outcrops. The Weber is Middle Pennsylvanian to Early Permian and represents the end of a marine to eolian depositional sequence that began with the deposition of the Pennsylvanian Round Valley Limestone.

0.6 9.4 Basal contact of the Permian Grandeur Member of the Park City Formation. The Grandeur Member is mostly sandstone and limestone.

0.1 9.5 **STOP 6** - Boundary of Sheep Creek Canyon Geological Area (cattle guard). The Park City and Phosphoria Formations crop out at the northeastern boundary of the geological area (figure 10). The Meade Peak Member of the Phosphoria Formation crops out along the road. Dark-gray phosphatic shale, a characteristic rock of the Meade Peak, is exposed. The phosphatic shale in the Meade Peak Member is an important economic commodity to the area. It is locally mined near Vernal, Utah for the phosphate (Schell and Dyni, 1973), which is processed into fertilizer. Phosphatic shale can also be rich in organic material and a source of petroleum. Oil produced from the Weber Sandstone reservoirs in the area is derived from the Meade Peak Member (Maughan, 1984; Sprinkel and others, 1997). The steep, thick cliff above the slope-forming Meade Peak Member is the Franson Member of the Park City Formation. It consists mostly of carbonate (limestone and dolostone) and sandstone.

Figure 9. Tower Rock in the northeast part of Sheep Creek Canyon Geological Area is composed of the upper Weber Sandstone (STOP 5). The upper part of the Weber is interpreted as being deposited in an eolian environment because it consists of quartz-rich, well-sorted sand grains, and contains large-scale cross-bedding. View to the northeast.

Figure 10. The Permian Park City and Phosphoria Formations crop out in the northeastern part of the geological area at STOP 6. The upper thick cliff is the Franson Member of the Park City Formation and the underlying slope that includes the thick carbonate ledge is the Meade Peak Member of the Phosphoria Formation. Phosphatic shale crops out right above the fence. The top of the Grandeur Member of the Park City is right above the loop road at the extreme left side of the photograph. View is to the south.

0.4 9.9 Continue east-northeast along graveled road. Sheep Creek Canyon widens to form an alluviated strike valley eroded into soft Triassic rocks. The gray, poorly vegetated rocks on the south are the Lower Triassic Dinwoody Formation. The Dinwoody is mostly marine mudstone, sandstone and thin lenses of limestone beds. The red rocks on the north are siltstone, sandstone, and mudstone beds of the Lower Triassic Moenkopi and Upper Triassic Chinle Formations. The Triassic section in Sheep Creek Canyon is thin because of faulting. The massive-weathering sandstone cliff above the red Triassic rocks is the Lower Jurassic Glen Canyon Sandstone. The Glen Canyon rocks are equivalent to (and may be more appropriately named) the Nugget Sandstone of western Wyoming and northern Utah.

0.4 10.3 **Dowd Grave site**. Cleophas J. Dowd (1857-1897) homesteaded Sheep Creek in 1885. Apparently a business partner or fellow rancher killed him. Dowd's grave is in Moenkopi Formation and was apparently not disturbed by the debris flow that swept through Sheep Creek Canyon in 1965.

0.6 10.9 Glen Canyon Sandstone forms the cliff on the north side of the road.

0.4 11.3 **Cattle guard**.

0.05 11.3 **Bridge** over Sheep Creek.

0.1 11.4 **STOP 7** - Park along the side of the road near the bridge. This location provides a view south of the Park City, Dinwoody, and Moenkopi Formations, and the Sheep Creek monocline. Hike south through Moenkopi and up the poorly vegetated Dinwoody slopes to examine the variety of rock types. The red rocks—the red color is caused by the oxidation of iron in the rocks—south of the road are the steeply dipping Moenkopi Formation. South of the red hills are the low, conical gray hills of the Dinwoody Formation. The Franson Member of the Park City Formation is the resistant cliff-forming unit that is folded into a north-dipping monocline. The monocline is probably due to faults under the Sheep Creek valley that moved during the Laramide orogeny between 70 and 40 million years ago. Typically, a monocline forms when a fault pushes up and cuts at depth but does not cut the overlying rocks, thus folding but not breaking the overlying rocks.

0.4 11.8 **Carmel Picnic Area** (193 on USFS maps). The rocks south of the picnic area consist of the Moenkopi Formation. The steep cliff north of the picnic area is the Glen Canyon Sandstone.

0.6 12.4 **Bridge**.

0.1 12.5 **STOP 8** - Intersection of Sheep Creek Canyon Geological Area loop road (USFS 218) with Utah Highway 44. The road cut through the Glen Canyon Sandstone is called Sheep Creek Gap. Northward through the gap, the overlying Carmel Formation and Entrada Sandstone are exposed. The Carmel is composed of a lower interval of gray limestone, sandstone, and mudstone, and an upper part of mottled red and gray mudstone, siltstone and some sandstone. Numerous beds of gypsum are also exposed in the Carmel. The Carmel represents marine to marginal marine deposition in an arm of a great seaway that extended into Utah. Overlying the Carmel is the Entrada Sandstone. The Entrada is the thick-bedded eolian (sand dune) unit that forms the resistant cliff.

END OF ROAD LOG.

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